An Internship Report

on

DESIGN ANALYSIS OF GRID-CONNECTED SOLAR ROOFTOP PHOTOVOLTAIC SYSTEM

in partial fulfillment of the award of the degree

of

BACHELOR OF TECHNOLOGY (B. Tech.)

IN

ELECTRICAL ENGINEERING

Submitted by:

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(*A Govt. Aided UGC Autonomous & NAAC Accredited Institute, Affiliated to RGPV Bhopal*)

MAY 2023

DECLARATION

I certify that the Internship report entitled on DESIGN ANALYSIS OF GRID-CONNECTED SOLAR ROOFTOP PHOTOVOLTAIC SYSTEM, submitted to the Electrical Engineering Department, is my original work.

The report has not been submitted elsewhere for the award of any other degree, diploma, fellowship, or similar titles. All information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I have fully cited and referenced all material and results that are not original to this work.

To the best of my knowledge, the material presented in this report has not been submitted to any other place (i.e. institute, university, organization) as a thesis/report except the industry, where this work has been carried out.

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Date: 20/05/2023
Place: Gwalior

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This is to certify that the above statement made by the candidate is correct to my knowledge and belief.

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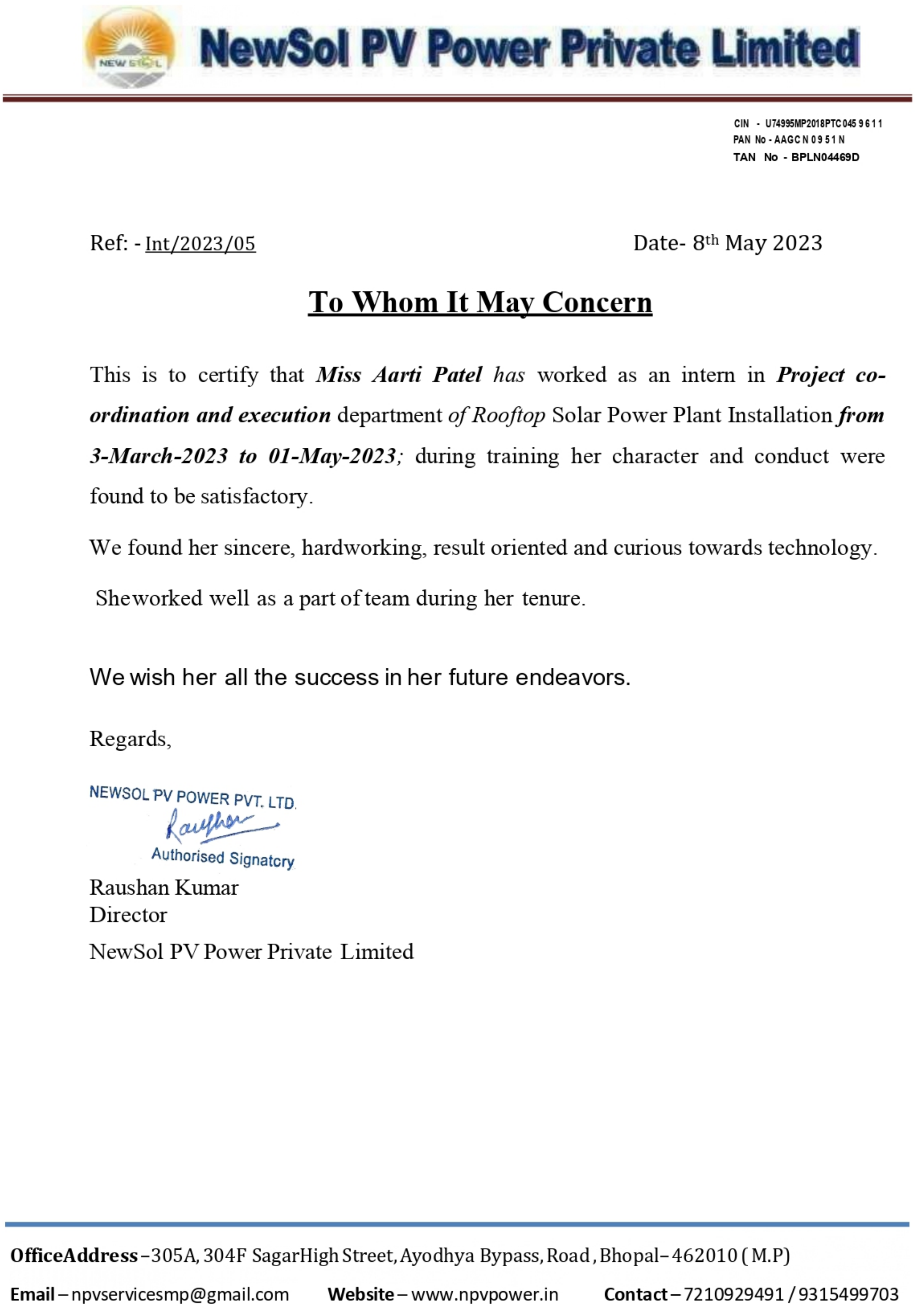
Date: 20/05/2023 **Aarti Patel**

Place: Gwalior **0901EE191001**

ATTACHED CERTIFICATE



NewSol PV Power Private Limited

CIN - U74995MP2018PTC0459611
PAN No - AAGCN0951N
TAN No - BPLN04469D

Ref: - Int/2023/05 Date- 8th May 2023

To Whom It May Concern

This is to certify that ***Miss Aarti Patel*** *has* worked as an intern in ***Project co-ordination and execution*** department *of Rooftop* Solar Power Plant Installation ***from 3-March-2023 to 01-May-2023****;* during training her character and conduct were found to be satisfactory.

We found her sincere, hardworking, result oriented and curious towards technology.

Sheworked well as a part of team during her tenure.

We wish her all the success in her future endeavors.

Regards,

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ABSTRACT

An internship report serves the purpose to record the details of my industrial training which was conducted in Newsol PV Power Private Limited, Bhopal which is a leader in the solar energy market, with business units focused on equipment supply services and project development. This report will cover the details of my internship duration of two months which began on 3rd March 2023 and ended on 1st May 2023.

As an engineering leadership trainee in an internship focused on solar rooftop systems, I had the opportunity to work on a 520 kW Solar car parking project, which was an exciting and challenging project. My primary role in the project was to oversee the design and installation of the solar panels, ensuring that they met the required specifications. One of the critical skills I developed during the internship was the ability to work effectively in a team. I worked closely with the project manager, other engineers, and contractors to ensure that the project was completed on time and within budget. We encountered several obstacles during the project, such as sourcing specific materials and equipment, and we overcome these challenges by collaborating and finding alternative solutions.

In addition to my role in the Solar car parking project, I also worked on tender and liaisoning work. I assisted in developing proposals and tender documents, which required me to research and understand the requirements of potential clients. I also liaised with various stakeholders,such as government officials, contractors, and vendors, to ensure that projects progressed smoothly.

During my internship, I also had the opportunity to conduct two case studies one is a commercial project at the Rajabhoj Airport in Bhopal and the one is a domestic project in which I compare two PV systems which are installed on the rooftop of our two clients. I conducted extensive research on the system, including its design, installation and performance. I also did the cost analysis including government subsidies provided for domestic users. The case study enabled me to gain a deeper understanding of solar power systems and their potential impact on the environment and society.

Overall, my internship in solar rooftop systems provided me with valuable insights and experiences. I developed technical and leadership skills, learned how to work effectively in a team, and gained a deeper understanding of solar power systems.

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LIST OF ABBREVIATIONS

AB - Air Breaker

ACB - Air Circuit Breaker

AC - Alternate Current

ACSR - Aluminum Conductors Steel Reinforced

CER - Carbon Emission Reduction

CO2 - Carbon Dioxide

CT - Current Transformer

DAS - Data Acquisition System

DC - Direct Current

DP - Double Pole

DPR - Detailed Project Report

HT - High Tension

LT - Low Tension

LV - Low Voltage

MNRE - Ministry of New and Renewable Energy

kWh - Kilowatt Hour

NO2 - Nitrous Oxide

MCB - Main Combiner Box / Miniature Circuit Breaker

MFM - Multi Function Meters

PLF - Plant Load Factor

PV - Photovoltaic

PT - Power Transformer

SEB - State Electricity Board

PREFACE

This report provides an in-depth analysis of the 520 KW solar car parking project that was installed at Raja Boj Airport Bhopal. The project was initiated as part of the airport's commitment to promoting sustainable and eco-friendly practices while meeting the energy needs of the facility. The project had several objectives, including reducing the airport's reliance on gridelectricity, promoting sustainable development, and reducing its carbon footprint. The project also aimed to demonstrate the economic viability of solar energy as a source of power for airport facilities. The report provides a comprehensive analysis of the solar car parking project, including its design, construction, and performance. The report also examines the benefits and challenges associated with the project and its potential for replication in other airports.

One of the key benefits of the solar car parking project is its potential to reduce the airport's carbon emissions. By generating renewable energy on-site, the project has helped the airport to reduce its reliance on grid electricity, which is typically generated from non-renewable sources. This has helped to mitigate the environmental impact of the airport's operations and promote eco-friendly practices in the aviation industry.

The project has also demonstrated the economic viability of solar energy as a source of power for airport facilities. While the initial investment in the solar car parking system was significant, the project is expected to generate cost savings over its lifetime by reducing the airport's energy bills and providing a source of income through the sale of excess solar energy back to the grid.

The report also highlights the challenges faced during the implementation of the project, including technical and regulatory hurdles. It examines how these challenges were overcome, providing valuable insights for airport operators and other stakeholders interested in implementing similar initiatives.

INTRODUCTION

In India, solar power generation is growing at an accelerated pace. Solar power is green and clean power. The grid-connected solar power plant nowadays is widely used in the domestic as well as at commercial sites like airports and railway stations. Grid-tied solar power plants are found to be very suitablefor airports as the load profile is generally in coherence with the generation profile. The 520 KW of solar power plant at Raja Bhoj airport in Bhopal is an on-grid Solar PV System. An on-grid solar power system is one that is connected to the local power grid, allowing excess electricity generated by the solar panels to be fed back into the grid for use by other consumers. This is in contrast to an off-grid solar power system, which is not connected to the grid and instead relieson batteries to store excess electricity for later use. The on-grid system allows the airport to benefit from the advantages of solar power generation while still being able to rely on the gridfor additional electricity when needed. The airport can also benefit from net metering, where excess electricity generated by the solar power plant can be credited towards the airport's electricity bill, reducing its overall energy costs.

Overall, the on-grid solar power plant is an important step towards promoting the use of renewable energy and reducing the carbon footprint of the airport. The solar car parking project implemented at the airport is a great example of how airports can reduce their carbon footprint and promote sustainable practices by using renewable energy sources. The project has demonstrated the technical and economic feasibility of solar energy as a source of power for airport facilities, and its success provides a valuable model for other airports around the world. This report aims to provide a comprehensive analysis of the project and its potential applications,contributing to the overall goal of creating a more sustainable aviation industry

1. Chapter I: Case study-1

1.1 Statement of Problem

The 520 KW of solar car parking project faced several challenges and issues during its development and implementation. One of the most significant problems was the complexity of the project, which involved several interdependent components and required close coordination between multiple stakeholders. One of the primary challenges of the project was the design and installation of solar panels in the car parking area. The car parking structure presented several design constraints, such as limited space and the need to maintain accessibility and safety for cars andpedestrians. As a result, the solar panel layout had to be carefully planned and optimized to ensure maximum energy production while minimizing shading and other performance limitations.

Another significant issue was the sourcing and procurement of the required materials and equipment. The project required several specialized components, such as solar panels, inverters, and mounting structures, which were not readily available in the local market. The procurement process was further complicated by the need to comply with local regulations and standards, such as the requirement for UL certification for certain components.

The installation and commissioning of the solar car parking system also presented several challenges. The installation required close coordination between several contractors and subcontractors, such as the civil works contractor, the electrical contractor, and the solar panel installer. The coordination was further complicated by the need to ensure compliance with local regulations and standards, such as the requirement for proper grounding and lightning protection. The commissioning of the system also presented several challenges, such as ensuring the proper configuration of the inverters and the communication between the various system components. The commissioning process required several rounds of testing and troubleshooting to identify and resolve any issues.

The project also faced several challenges related to the operation and maintenance of the solar car parking system. The system required regular maintenance, such as cleaning the solar panels and monitoring the performance of the inverters and other components. The maintenance was further complicated by the need to ensure the safety of the workers and the users of the car parking structure. Another significant issue was the integration of the solar car parking system with the local power grid. The integration required close coordination with the local utility and the installation of several additional components, such as net metering and interconnection equipment. The integration was further complicated by the need to ensure compliance with local regulations and standards, such as the requirement for proper protection and synchronization.

In conclusion, the 520 KW solar car parking project faced several significant challenges and issuesduring its development and implementation. These challenges included the complexity of the project, the sourcing and procurement of materials and equipment, the installation and commissioning of the system, the operation and maintenance of the system, and the integration with the local power grid. These challenges required close coordination and collaboration between multiple stakeholders, such as the project owner, contractors, subcontractors, and the local utility. By overcoming these challenges, the project was successfully completed and has since provided a reliable and sustainable source of energy for the car parking structure and the Airport community.

Case study-2: In this case study we compare our two projects at two different Site locations.

Name of the Customer	Bhopal, MP	Dr N. Kukreja
Locality	2 KW	Bhopal, MP
The capacity of Solar PV Rooftop Systems	Gautam Monocrystalline Solar Panels	2 Kw
Solar PV Modules	EVVO Inverter	Gautam Monocrystalline Solar Panels
Inverter	160 square feet	EVVO Inverter
Total Area Required	Single phase	160 square feet
Net meter arrangement	70 Rs	Single phase
Per watt project cost	1,40,000 Rs	70 Rs

Total cost for 3/2 KW system	16,800 Rs	1,40,000 Rs
GST 12%	1,56,800 Rs	16,800 Rs
Total project cost	29,176 Rs	1,56,800 Rs
Subsidy credited to customer’s account	1,27,624 Rs	29,176 Rs
Net amount paid by the customer	1,76,636 Rs	1,27,624 Rs

2.1. Purpose of Study

India is both densely populated and has high solar insolation, providing an ideal combinationfor Solar Power in India. Power is the lifeline of any development of the nation. At present the power requirement is being met by three main sources viz., Thermal, Hydel and Nuclear. While Hydel and Nuclear have their inherent limitations, Thermal Power is often confronted by the challenge associated with the availability of fuel. Currently, Thermal Power stations which meetthe major part of the power demand use coal as fuel. Conventional fuels such as oil, gas and coal cannot meet the increasing demand forever. In addition to the requirement of huge funds, the implementation of more such projects using conventional means of power generation will also involve issues of growing environmental concern, with the depletion of fossil fuels.

1. In order to bring down the dependence on finite fossil fuels for power generation, it is necessary to look into the viability of generating power locally using renewable energy sources.
2. Fortunately, India lies in sunny regions of the world. Most parts of India receive 4.7 kWh of solar radiation per square meter per day with 300-325 sunny days in a year. India has abundant solar resources, as it receives about 3000 hours of sunshine every year, equivalent to over 5,000 trillion kWh. India can easily utilize solar energy. Today The Government is encouraging the generation of electricity from various renewable energy sources such as wind, solar, small hydro, and biomass by giving various fiscal & financial incentives. This apart, the state governments are

procuring electricity from renewable energy projects at preferential tariffs. So far 29,536 MW of renewable power capacity have been installed in the country, which includes 19,933 MW from wind, 2079 MW from solar, 3746 MW from small hydro and 3776 MW from bioenergy. The Ministry of New and Renewable Energy is providing various renewable energy systems for the decentralized generation of electricity. So far, 10,752 villages have been electrified using various renewable energy systems. About 2.55 lakh solar street lights, 9.93 lakh solar home lighting systems, 9.39 lakh solar lanterns and 138 MW of decentralized solar power plants have been installed.

Fig.1 Budget 2023-24: Govt prioritizes energy security

The Government of India has separately set up a Ministry called MNRE - Ministry of New Renewable Energy for the promotion of Power Generation through Renewable Energy. TheMinistry has been facilitating the implementation of a broad spectrum including harnessing renewable power/ Energy (make use of one) and renewable energy to rural areas for lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications.MNRE has announced a host of fiscal incentives such as concessional custom duties, exemptionof excise duty and accelerated depreciation for Solar PV based Power Plan ts. At the State level, the promotion of Solar Power generation is being encouraged by local policies that cover buyback, wheeling and banking of the generated electricity by State Electricity Boards, besides otherincentives.

1. Considering the good potential of Solar Power and also the trust given by the Central & State Governments in utilizing the abundant Solar Power in the State of Madhya Pradesh for Power generation, **Rajabhoj Airport Bhopal** proposes to set up a 520KWp Solar PV based Power Plant in the Car parking area.
2. This Technical Proposal highlights the implementation of a 520KWp Solar PV based Power generation project in Madhya Pradesh state under Independent Power Producer (IPP) mode.
3. The proposed Power Plant will have Solar PV modules, String Inverters as the major components & other accessories for Power production.
4. All the necessary auxiliary facilities of the Power Plant like Plant Monitoring System, Safety equipment, Instrumentation, Control system etc., will be provided for the Power Plant. The water requirement for the module cleaning & for other requirements can be met from bore wells at the site.
5. The site selection for a Solar Power Plant is predominantly determined by solar isolation availability & grid connectivity for exporting power. The proposed site where Rajabhoj Airport Power Plant is to be located in Madhya Pradesh is found to favour the above factors to a great extent.
6. The Plant and equipment facilities will be designed to comply with all applicable stipulations/guidelines of statutory authorities such as State and Central Pollution Control Boards, Electrical Inspectorate, Inspector of Factories etc.
7. The net send output power available from 520KWp Power Plant is estimated to be 949 MWh per annum for crystalline modules.
8. This report highlights the details of the proposed Power generation scheme, site facilities,

features of the main plant, electrical systems evacuation of generated power, environmental and safety aspects, distribution mechanism, Cost estimation, risk mitigation plan and Project viability. It also highlights the complete schedule for the project implementation.

lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications.

Description of Terms

The solar car parking project at the airport area is a renewable energy project that utilizes solar energy to provide power to a car parking structure. The project involves the installation of solar panels on the car parking structure, which convert sunlight into electricity that is fed into the local power grid. In this article, we will describe some of the key terms and concepts related to the solar car parking project.

Solar panels:

Solar panels are the primary components of the solar car parking system. They are designed to capture sunlight and convert it into direct current (DC) electricity. Solar panels are typically made up of photovoltaic cells, which are the basic building blocks of solar panels. When sunlight hits a photovoltaic cell, it causes a flow of electrons that generates an electrical current. The more cells that are combined, the more electricity that can be generated.

Inverter:

The inverter is a critical component of the solar car parking system as it converts the DCelectricity generated by the solar panels into AC electricity that can be used to power the car parking structure and the surrounding area. The inverter is typically located near the solar panels and is connected to the local power grid. It is designed to ensure that the electricity generated by the solar panels is compatible with the local power grid.

Inverters come in different types and sizes, depending on the size of the solar car parking system. They are typically rated by their maximum output capacity, which is measured in kilowatts (kW).

Mounting Structures:

Mounting structures are used to hold the solar panels in place on the car parking structure. They are typically made of steel or aluminium and are designed to withstand the weight of the solar panels and the weather conditions in the local area. Mounting structures must be properly designedand installed to ensure that the solar panels are securely attached to the car parking structure. Theymust also be installed in a way that allows for easy maintenance of the solar panels.

Net metering:

Net metering is a billing arrangement between the owner of the solar car parking system and the local utility. Under net metering, the owner of the system is credited for any excess electricity generated by the solar panels that is fed into the local power grid. The credits can be used to offset the owner's electricity bills.Net metering is an important part of the 520 KW solar car parking project as it allows the owner of the system to benefit from the excess electricity generated by the solar panels. This can result in significant cost savings over the life of the system.

Interconnection Equipment:

Interconnection equipment is used to connect the solar car parking system to the local power grid. The interconnection equipment typically includes a meter, a circuit breaker, and other safety devices that ensure that the solar car parking system is safely and properly connected to the grid.

Interconnection equipment must be properly installed and maintained to ensure that the solar car parking system operates safely and effectively. This equipment is typically installed by an electrical contractor.

UL Certification:

UL certification is a certification provided by Underwriters Laboratories, which is an independent organization that tests and certifies products for safety and performance. Many of the components of the solar car parking system, such as the inverters and mounting structures, may require UL certification to ensure that they

Civil works contractor:

This is the contractor responsible for the construction of the car parking structure. The civil works contractor is responsible for ensuring that the car parking structure is built to the required specifications and is compatible with the installation of solar panels.

Electrical work:

This is the contractor responsible for the electrical installation of the solar car parking system. The electrical contractor is responsible for installing the wiring, inverters, and other electrical components of the system.

Overall, the 520 KW solar car parking project at the airport area is a complex renewable energy project that requires close coordination and collaboration between multiple stakeholders. The project involves the installation of solar panels, inverters, mounting structures, and interconnection equipment, as well as coordination with the civil works contractor and electrical contractor. By leveraging solar energy, the project provides a sustainable and reliable source of electricity for the car parking structure and the surrounding area.

Classification of photovoltaic system

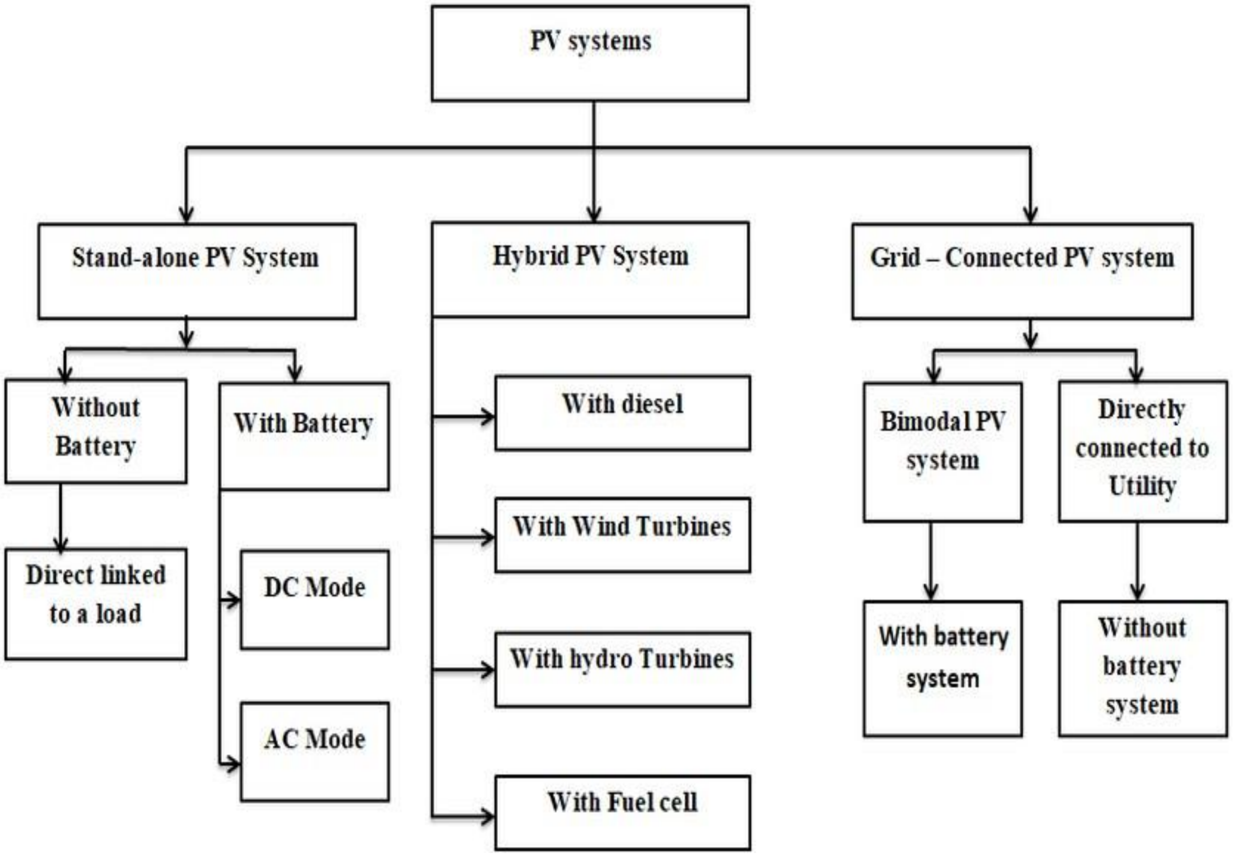


Fig.2 Classification of a Solar Photovoltaic System

2. Chapter II: Conceptual Framework

2.1 Project Implementation Strategy

It is envisaged that the project will have the below mentioned phase of activities. These phases are not mutually exclusive; to implement the project on a fast track basis some degree of overlapping is envisaged.

Phase I - Project Development
Phase II - Finalization of the Equipment and accessories
Phase III - Procurement and Construction
Phase IV - Plant Commissioning

Phase I - Project Development

In a power project, development of project development plays an important role. Almost 50 % of the work is done if one achieves a power purchase agreement from the respective state utilities. The project development starts with visits to the region, understanding about the regional conditions, socioeconomic conditions, transportation facilities and infrastructure facilities available in the region. Apart from the above the below listed tasks will be under project development:

- Preparation of Detailed Project Report (DPR)
- Submission of DPR
- Power purchase agreement (PPA)
- Expedite Central Regulatory Authority clearance
- Land acquisition/mortgage

During this phase, a project team will be formed during the execution of the project. The engineers from the group will be involved from the early stages of the execution of the project. This would give them the opportunity to familiarize themselves with the equipment and systems being installed. This personnel should be involved with the critical team of installation and commissioning. After the plant is commissioned, these engineers and technicians would occupy key positions in the organization structure for the operation and maintenance of the plant.

The responsibilities of the project team shall be:

- Planning and programming of all the resources required for project completion
- Inspection of major fabrication items

- Organize the construction and commissioning of the plant
- Monitoring and controlling the project progress
- Execute the project within the planned budget

Phase II- Finalization of The Equipment and Contracts

The Power Plant modules and inverters are the lead items and the planning schedule for the project implementation should provide an adequate time period for the acquisition and installation of these equipment. The specifications for major equipment shall be drawn up at an early stage of the project. A program of design information, from the equipment suppliers, that satisfies the overall project schedule shall be drawn up. Since, the project execution calls for closer coordination among the contractors, consultants and the company, proper contract coordination and monitoring procedures shall be made to plan and monitor the project progress.

Phase III - Procurement And Construction

Procurement is an important function of the implementation of the project. Once the purchaseorder is placed, the project team follows up regularly to ensure smooth and timely execution of thecontract and for obtaining technical information for the inter-package engineering. When thecontracts for the equipment are awarded, detailed programs in the form of a network are tied upwith the supplier to clearly indicate the owner's obligations and the supplier’s responsibilities. Andupon placement of the purchase order, the project team follows up regularly to ensure smooth and timely execution of the contract and or obtaining technical information for the inter-package engineering. The procurement activity includes a review of drawings, expediting, stage and final pre-delivery inspection, supervision of installation and commissioning. During Construction, the erection and commissioning phases of all the contracts proceed simultaneously. Adequate power and water shall be made available for the construction. The construction manager takes t overall responsibility for the site.

Phase IV- Erection and Commissioning Phase

The commissioning phase in a project is one where design, manufacturing, erection and quality assurance expertise are put to the test. The commissioning team will be from the manufacturer of the equipment, the consultant and the company. As discussed in the earlier section, staff identified to operate the plant will be involved in the commissioning phase of the project itself. When the construction phase is complete, the checklist is designed to ensure that the plant has been properly installed with appropriate safety measures. The commissioning team will follow the internal operating instructions. The plant shall be subjected to a performance test.

Project Schedule

The overall Project completion is scheduled for 3 months from the date of finalization of the contract.

2.2 Basic System Description

A conceptual framework for a 520 KW solar PV installation at an airport would involve several key elements and considerations. Here's an overview of the framework:

Solar Resource Assessment:

Conduct a detailed assessment of the solar resource at the airport location to determine the solar irradiance levels throughout the year. This assessment helps estimate the potential energy generation from the solar PV system.

Load Analysis:

Analyze the airport's electricity consumption patterns to understand the energy demand and peak load requirements. This analysis assists in sizing the solar PV system appropriately to offset a significant portion of the airport's energy needs.

Site Assessment and Design:

Evaluate the available space within the airport premises for solar panel installation. Consider factors such as the orientation, tilt angle, shading, and structural integrity of the identified areas. Design the layout and configuration of the solar panels for optimal sunlight exposure and maximum energy generation.

System Sizing:

Based on the solar resource assessment and load analysis, determine the appropriate capacity of the solar PV system to meet the airport's energy requirements. In this case, the system should be designed to generate a total capacity of 520 KW, taking into account factors such as average annual energy consumption and the desired percentage of energy offset.

Component Selection:

Select high quality solar panels, inverters, mounting structures, and other necessary components based on their efficiency, reliability, durability, and compatibility with local conditions. Consider factors such as product warranties, performance guarantees, and maintenance requirements.

Grid Interconnection:

Determine the integration of the solar PV system with the existing electrical infrastructure at the airport. Assess the grid connection requirements, such as grid capacity, voltage levels, and regulatory approvals. Install the necessary equipment, such as grid-tie inverters, to synchronize the solar PV system with the grid and enable net metering or feed-in tariff arrangements.

Monitoring and Control:

Implement a comprehensive monitoring and control system to track the performance of the solar PV installation. This system should provide real-time data on energy generation, system efficiency, and any issues or faults. It should also enable remote monitoring and facilitate proactive maintenance and troubleshooting.

Financial Analysis:

Conduct a financial analysis, including the evaluation of the project's economic viability, return on investment (ROI), and payback period. Consider factors such as capital costs, operational expenses, available incentives or grants, electricity tariff structures, and potential savings from reduced energy bills.

Environmental Impact:

Assess the environmental benefits of solar PV installation, such as reduced greenhouse gas emissions and carbon footprint. Consider any local regulations or sustainability goals that may influence the design and implementation of the system.

Operations and Maintenance:

Develop an operations and maintenance plan to ensure the long-term performance and reliability of the solar PV installation. This plan should include regular inspections, cleaning, performance testing, and preventive maintenance activities. It should also outline procedures for addressing any operational issues or component failures promptly. By considering these key aspects and integrating them into a cohesive conceptual framework.

2.3 Operation Philosophy

Solar panels mounted in the field generate DC electric power. The DC electric power generated by the solar panels cannot be fed directly into the utility grid. The inverters invert the direct current output from the solar array into grid-compliant AC voltage, feeding it into the utility grid system with proper protection and control. The grid-connected inverter (GCI) range of inverters comes with a built-in transformer that ensures galvanic isolation of the DC side from the AC network. This is an important requirement for many utilities to permit the connection of solar panels to the grid. The system automatically starts up in the morning and begins to export power to the grid, provided there is sufficient solar energy and the grid voltage, and frequency is within the range. If the grid goes out of range the inverter will be immediately disconnected and reconnected automatically at a predetermined time after the grid comes back within range.

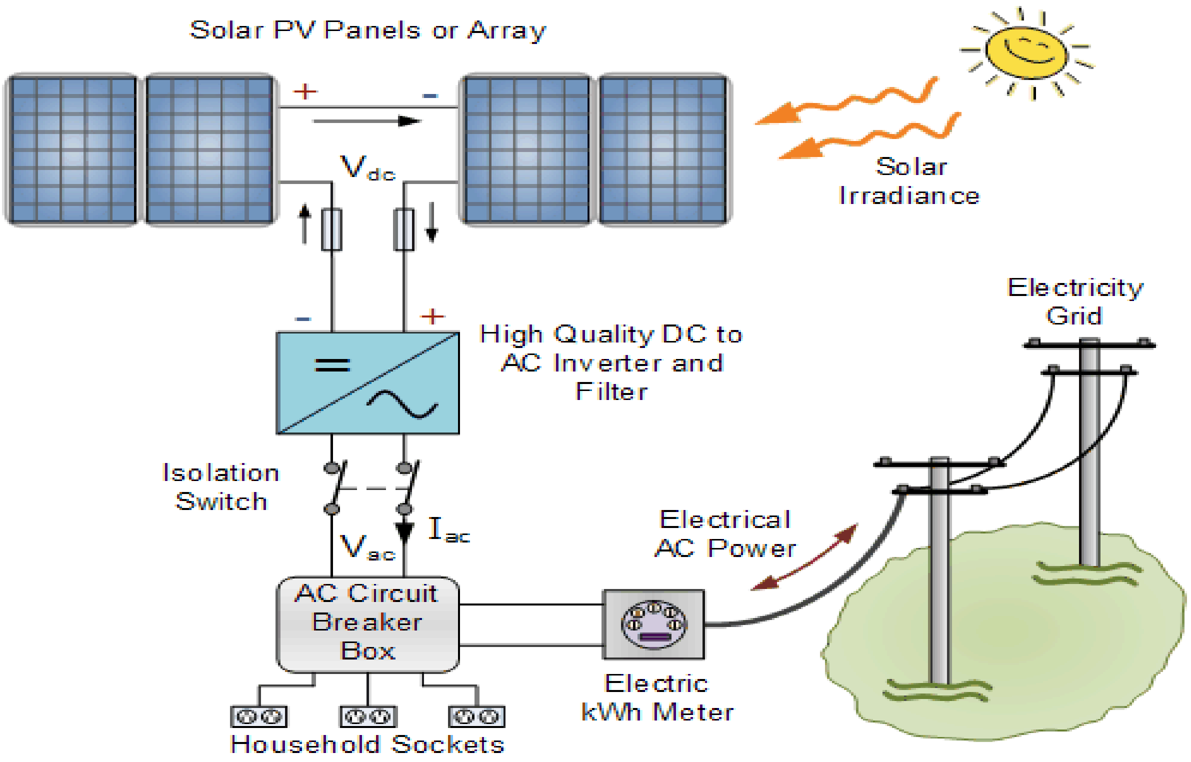


Fig.3 Simplified Grid Connected PV System

Grid-connected PV systems always have a connection to the public electricity grid via a suitable inverter because a photovoltaic panel or array (multiple PV panels) only deliver DC power. As well as the solar panels, the additional components that make up a grid-connected PV system compared to a stand-alone PV system are:

1. Inverter
2. Electricity Meter
3. AC Breaker panel and Fuses
4. Safety switches and cabling
5. The Electricity Grid

A grid-connected system without batteries is the simplest and cheapest solar power setupavailable, and by not having to charge and maintain batteries they are also more efficient. It is important to note that a grid-connected solar power system is not an independent power source, unlike a stand alone system. Should the mains supply from the electrical grid be interrupted, the lights may go out, even if the sun is shining. One way to overcome this is to have some form of short-term energy storage built into the design.

3. CHAPTER III: Methodology

3.1 Proposed Power Plant

Considering the good potential available and also the trust given by the Government of India and State Government to this national endeavor of exploiting renewable sources of energy for power generation and with the availability of abundant Solar Power Rajabhoj Airport is proposing to set up a 520KWp Grid connected Rooftop Solar PV Power Plant in Bhopal. The proposed Power Plant site is well connected & all necessary infrastructure facilities are available in & around the site. The proposed plant will have crystalline modules, module mounting structures, inverters and all accessories as the major components.

Technical specification of the 520 KW power plant:

No. of Modules	960
Panel Capacity	540 watt
PV Technology	Mono-crystalline half-cut
Module Manufacture	Sova Solar
Area	31200 square feet
Tilt angle	12°
Tracking System	No Tracking System
No. of Inverters	4 (125 Kw per inverter)
Inverter Manufacture	Growatt
DCDB box	8
ACDB box	2
MPPT	20 per inverter
No of strings	20 per inverter
Connection of panels	Series
Cables	AC and DC (4 square mm)

Solar Plant Layout of Parking Area

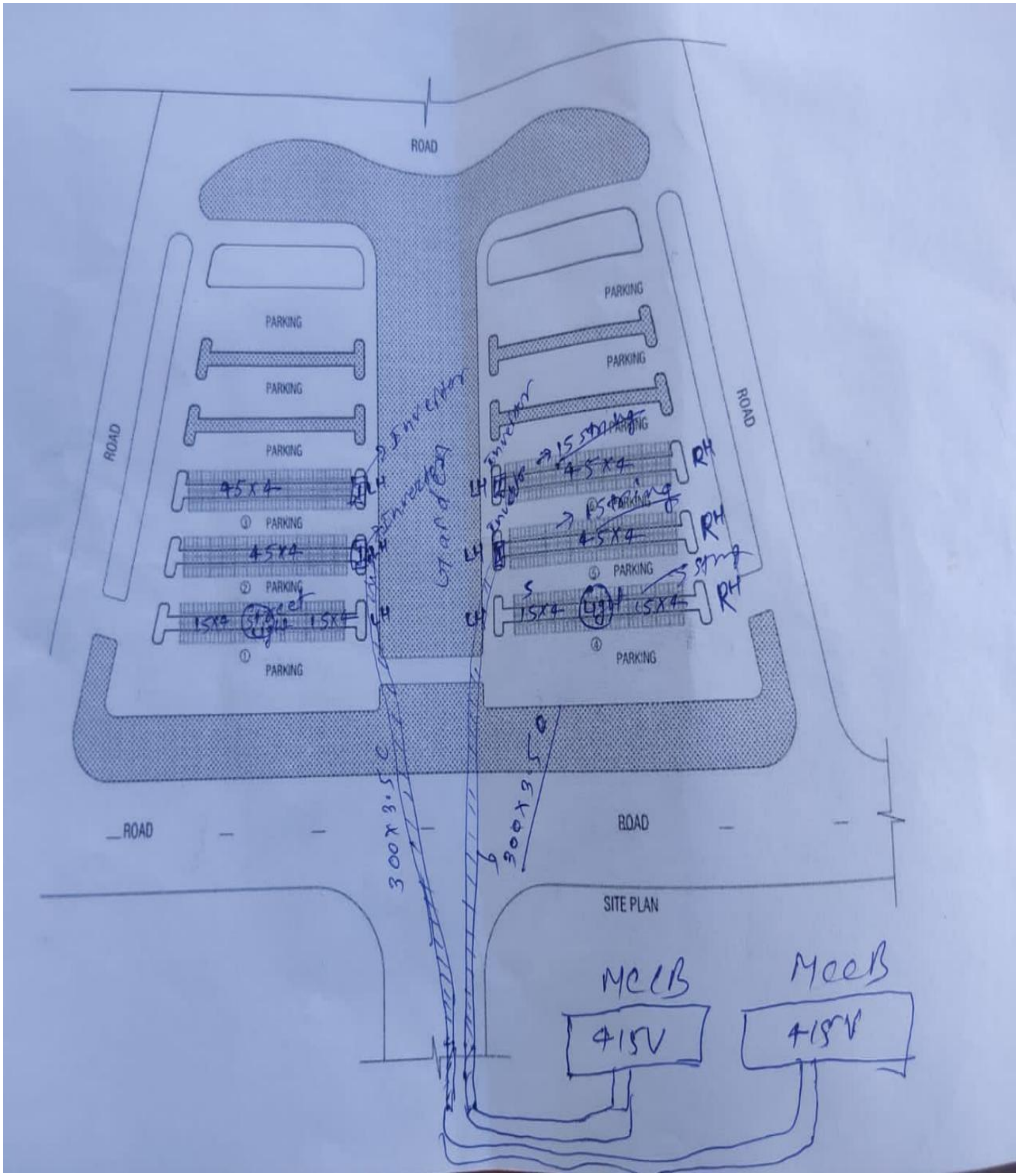


Fig.4 Solar Plant Layout

3.2 Site Selection and Design Assumption

The total area required for installing the 520KWp solar Power Plant is approximately 31200 square feet.

1) For a complete reliable system and to ensure high energy yield from the plant, innovative components with the latest technology are selected. The inverter that is selected is of very high efficiency over a wide range of loads. The inverter operates in excess of 95.0% efficiency.

2) We have understood the monitoring system requirement for such a large power plant and have proposed our state of the art monitoring and analysis central system. A few features are presented as follows:

- Monitors the performance of the entire power plant (string-wise monitoring, junction boxes, inverters, etc.)
- Evaluates (strings, inverter, nominal/actual value), quantity of DC Power & AC Power Produced.
- Measures instantaneous irradiation level and temperature at the site. It also measures the module back surface temperature.
- Alerts in case of error (discrepancy in the normal operation of components, like module string/ diodes/ inverter/ junction box/loose contacts/ etc.) to facilitate recognition and correction of the fault with minimum downtime.
- Visualizes nominal status of the connected components via Control Center PC Software (diagnosis on site or remote)
- Logs system data and error messages for further processing or storing
- Stores and visualizes energy yield data (for the life of the plant) in the Portal from where the data can be accessed remotely.

3) We have adopted the best engineering practice for complete cable routing in the power plant by using minimal cable length while connecting in a series string, using optimal size cables to ensure the entire plant cable losses are minimum.

4) The junction boxes proposed are completely pre-wired to ensure ease of installation, and maintenance and eliminate any installation hassles. These junction boxes not only combine the

DC power from strings but also monitor each string performance and feed the same data to the central monitoring system.

Design Assumption for Crystalline Modules:

Location: BHOPAL

Place of installation: RAJA BHOJ AIRPORT

Latitude: 23.193040

Longitude: 77.414860

Elevation: 75 m

Annual Solar radiation: 5.22 kWh/ Square meter/day

Module Facing: True South

Module Tilt angle: 12°

Type of System: Grid-Connected System

Sun hours: 8.30 – 4 Hrs.

Modules in series per String: 12 panel

Shading: No Shading

NOCT: 45°C

Module efficiency loss: 2.5%

Power loss at MPP: 2%

Soiling loss: 2%

3.3 Components of the solar system

As the Customer would like to explore the various options of Solar PV Technology, the Design Team would like to propose the best components that are available in the market. The following are the major components that would be discussed in the following section.

A. Module Mounting Structure

B. Solar Modules

  a. Crystalline Modules – Multi & Mono

C. Inverter

  a. String Inverter

D. Balance of System

  a. Junction boxes

  b. Cables

  c. Monitoring System

  d. Earthing & Lightning Protection

1.Solar Mounting Structure:

The module mounting structure is designed for holding a suitable number of modules in series. The frames and leg assemblies of the array structures are made of MS hot dip galvanized of suitable sections of Angle, Channel, Tubes or any other sections conforming to IS:2062 for steel structure to meet the design criteria. All nuts & bolts considered for fastening modules with this structure are of very good quality of Stainless Steel. The array structure is designed in such away that it will occupy minimum space without sacrificing the output from SPV panels at the same time it will withstand severe wind speed up to maximum 100 kmph.

Structure specification

Material	Hot Dip GI
Overall dimension	As per design
Wind rating	100 Km/hr
title angle	12 Degree

Fig.5 Mounting Structure

2. PV Array:

The total solar PV array installed capacity is 520kW. The individual PV module rating is 540 watts. The PV array consists of framed half-cut mono-crystalline. A suitable number of solar PV modules are connected in series strings and a suitable number of series strings are connected in parallel to formulate a series-parallel array. The maximum DC output voltage of the array is nearly 600 V. Conversion efficiency of the plant is approximately 15.5%. The front surface of the module consists of impact resistant low iron and high transmission toughened glass.

For each of the solar panels the corresponding data available are as below-

Panels specifications

Voc	49.62V
Isc	13.87A
Vmp	541.67V
Imp	12.96A
No of cells	144
1 solar cell	0.5V
Connection	Series
Operating voltage	30V

Fig.6 Solar PV Array

3. Inverter:

There are two PCUs used to convey the DC power produced by SPV modules into AC power and adjust the voltage and frequency levels to the local grid connection. Those PCUs areprovided with the Maximum Power Point Tracking (MPPT) features so that the maximum possible power can be obtained from the PV module. There are 3 MPPTs and those are connected in the asymmetrical manner (3/3/4). PCUs are capable of disconnection automatically in the event of grid failure. The PCUs have internal protection against sustained faults and lightning in DC and mains AC grid circuits. The sine wave output of the inverters is suitable to connect to the AC LT voltage grid. The internal connections in a PCU are shown in Fig7.

Inverter specification

Maximum apparent power	137.5kVA
Nominal input voltage	600 V DC
Maximum PV voltage	1100 V DC
Nominal output voltage	230/400 V AC
Power factor range	0.8leading~0.8lagging
Maximum output power	125kW
Safety level	Class I
Nominal output frequency	50/60 Hz

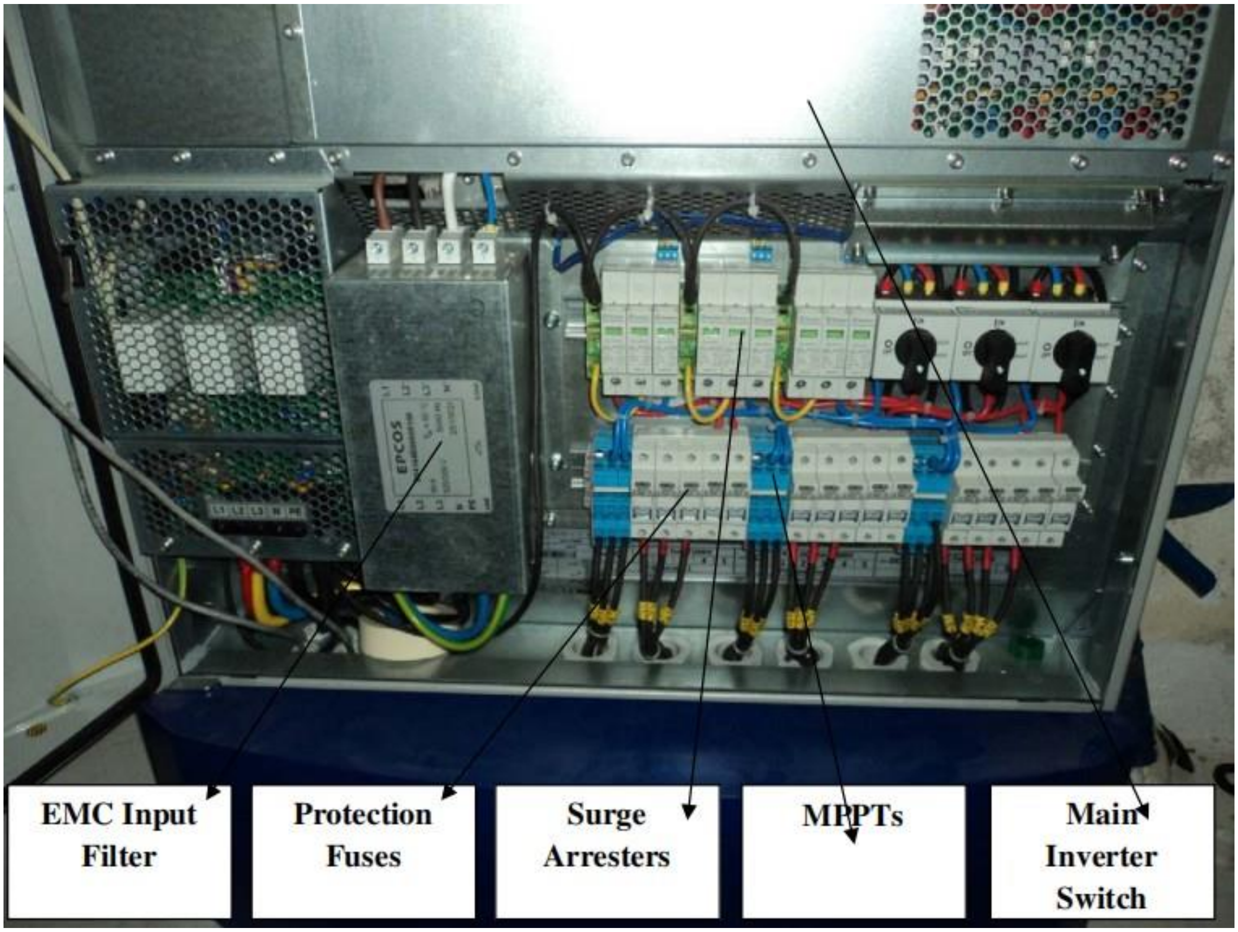
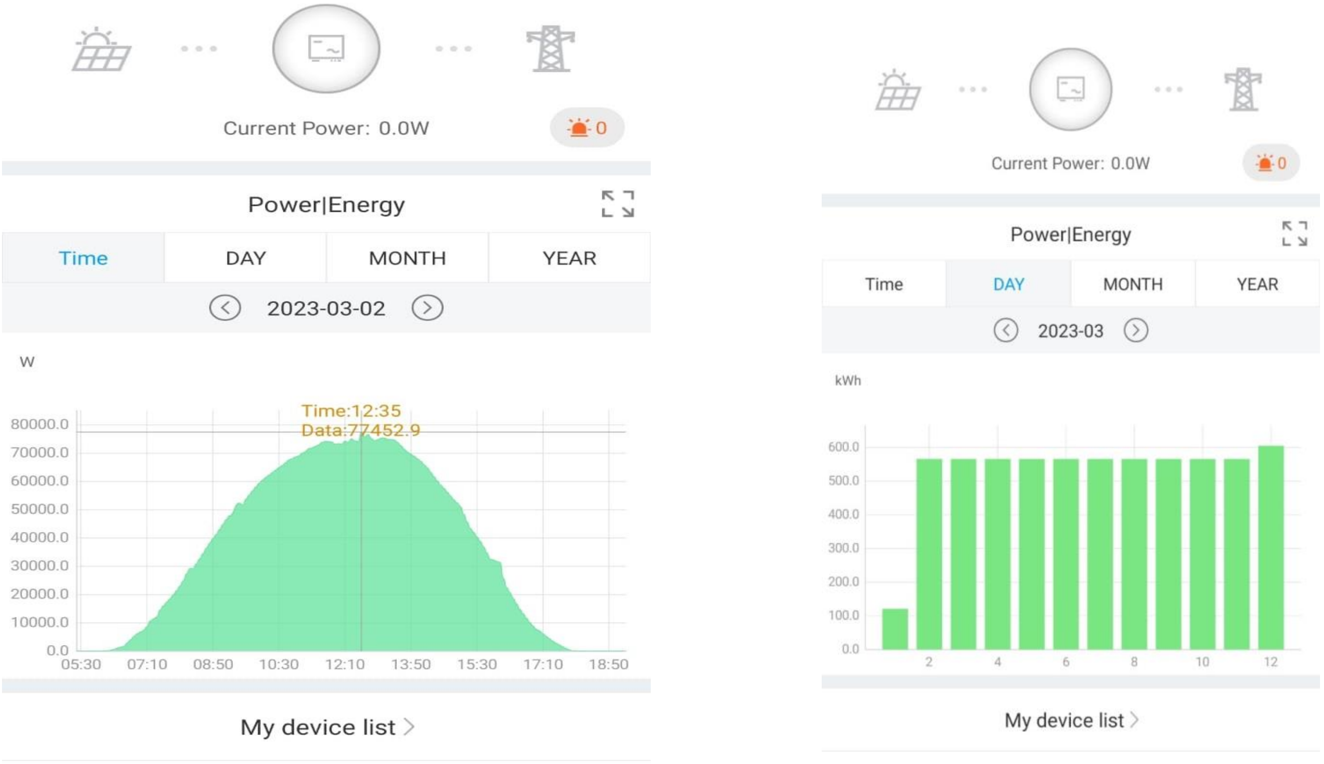


Fig. 7 Inside and outside view of an Inverter


Current Power: 0.0W

Time: 2023-03-02

Time:12:35
Data:77452.9

Current Power: 0.0W

DAY: 2023-03

Fig. 8 Reading recorded by a mobile application Shine Phone

4. Junction Boxes:

In the Junction boxes, individual module strings are bundled and safely routed to the inverter. It is a combination of an exact, well-organized string monitoring system and a safety concept adapted to PV technology. The junction boxes will have suitable cable entry points fitted withcable glands of appropriate sizes for both incoming and outgoing cables. They monitor the output of solar PV arrays. If the difference between string outputs is too large, the operator is informed through a monitoring system. Active disconnection allows string voltages to be measured separately.

AC Distribution Box

The solar AC Distribution Board is the panel used between the solar Inverter and Load to provide overload and short circuit protection. Normally these panels have one power input controlled by MCB, MCCB or Fuse multiple load feeders that use an energy meter to measure total load consumption. All the components are assembled in a suitable powder-coated metal enclosure.

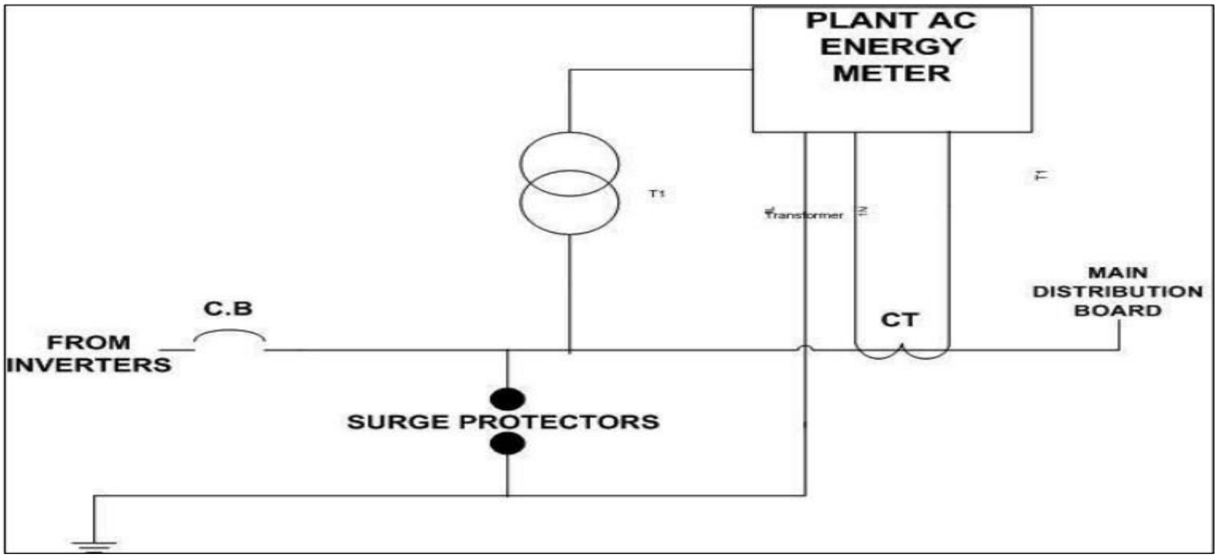


Fig. 9: Schematic Diagram of ACDB

Fig.10 ACDB BOX

5. Dc Distribution boxes

The DCDB box is made of epoxy powder-coated metal casting. Three feeders are provided in ACDB with MCB of required capacity installed at each feeder in the ACDB. One electronic energy meter, ISI make is provided in ACDB to measure the consumption of power from SPV power plants. A separate dedicated feeder from the conventional line to the inverter as well as ACDB is also provided.

Fig.11 DCDB Box

6. DC Cables And AC Cables:

The main DC cable is the larger collector cable. They connect the positive and negative cables from the generator junction box to the central inverter. Also, they can be single-core or twin-core cables. Single-core wires with double insulation are a practical solution to provide high reliability. At the same time, it is best to use two-core DC cables for the wiring between the solarinverter and the generator junction box. The size of the DC cable is 4mm.

The connectors/lugs of copper material with high current capacity and easy mode of assembly are proposed.

Specification of AC and DC cables

Type	PV Insulated, sheath & UV resistant
Material	Copper
Temperature	10-70 °C
Voltage	Max. 1100V for DC
Colour	Red/ Black /Yellow/Green

3.4 Protection System

Lightning Protection:

The SPV Power Plant shall be provided with lightning & over-voltage protection. The main aim of this protection shall be to reduce the overvoltage to a tolerable value before it reaches the PV or other subsystem components. The source of overvoltage can be lightning, atmosphere disturbances etc. Metal oxide varistors shall be provided inside the Array Junction Boxes. In addition, suitable SPDs also shall be provided in the Inverter to protect the inverter from overvoltage. The Power Plant components are selected & discussed in the previous chapter. Based on the component selection the Power Plant Design is discussed in this chapter.

Earthing:

The array structure of the PV yard will be grounded properly using an adequate number of earthing kits. All metal casing/shielding of the plant shall be thoroughly grounded to ensure the safety of the power plant.

3.5 Monitoring System

Monitoring systems are mainly used to monitor the performance of the Inverters, energy yield, temperature, irradiance level etc. It provides an extremely flexible interface to facilitate PC-based inverter monitoring via analogue modem, GSM, Ethernet, or Internet connections.

Industry-Leading Features and Performance:

- Inverter monitoring parameters include energy yield, power, array voltages, arraycurrents and AC parameters.
- Environmental-sensor interface capabilities include temperature, wind speed, and irradiation sensors.

Field-Proven Reliability:

- Enhanced remote-monitoring capabilities enable the collection and analysis of critical data
- needed to facilitate increased power system reliability.

Installer Friendly:

- A front-mounted LCD display provides visual confirmation of all critical operating parameters.
- Compact easy-to-install package with readily-accessible electrical connections.

Unmatched Applications Flexibility:

- Active alarm management capabilities with automatic delivery of SMS (GSM mode), e-mail, or fax alarm messages.
- Data logger and display-enabled configurations are available.

Chapter IV: Findings and Discussion

4.1 Description of Findings

String Calculation

String: A panel string is a collection of panels that are connected to your power inverter's singular input. A solar panel or PV module is made up of several cells, and a solar array is made upof several solar panels that have been connected in series or parallel. A string consists of solar panels that are wired in a series set to one input on a solar string inverter.

Array: A photovoltaic or PV array is created when two or more solar panels are connected. The number of solar panels that can be connected to an inverter to get the greatest results is shown by the string sizing. The inverter voltage capability is one of many variables that affect output quality.

In Airport,

Total capacity of project = 520 KW

Inverter power rating = 125 KW

no. of string in inverter = 20 (it means we can connect 20 strings to 1 inverter)

As mentioned in the parking area layout there are 4 array rows of 45*4 panels and 2 array rows of15*4 panels.

Panels connected in 1 inverter = KW rating of inverter/Power rating of 1 panel

= 125 KW/ 540 W

= 231~ 232 panels

Panels in 1 string = Panels connected in 1 inverter/ No of strings in inverter

= 232/ 20

= 11.6 ~ 12 panels

If we calculate for the overall plant, then

Total no of panels = 960

no of strings in all 4 inverters = 20*4 = 80

Panels in 1 string = Panels connected in 4 inverters/ No of strings in 4 inverters

= 960/80

= 12 panels

so, we can connect 12 panels in one string.

Calculations of Power generation by 520 KW Plant

Power generated in 1 kw plant = 5 units (Per day)

Power generated in 520 kw plant = 520*5
= 2600 units (Per day)

Power generated in one month = 2600*30
= 78000 units

Power generated in 1 year = 9,36,000 units (approximately)

4.2 Summary

A 520 KW solar PV installation in a car parking area refers to the installation of a solar power system with a capacity of 520 kilowatts. The system is designed to generate electricity using photovoltaic (PV) panels installed in the parking area. Here is a summary of the installation: Capacity: The solar PV installation has a total capacity of 520 kilowatts, which indicates the maximum power output the system can generate under optimal conditions.

PV Panels: The installation consists of a substantial number of PV panels that convert sunlight into electricity. These panels are typically made up of multiple solar cells connected in series and parallel to achieve the desired capacity.

Car Parking Area: Solar PV panels are strategically installed in the car parking area to utilizethe available space effectively. They are mounted on structures such as canopies or shades abovethe parking spaces, allowing for dual use of the area for both parking and solar power generation. Electricity Generation: When sunlight falls on the PV panels, it excites the electrons in the solar cells, creating a flow of electric current. This generated electricity is in direct current (DC) form, which is then converted into alternating current (AC) through inverters to match the electrical grid's requirements.

Grid Connection: The solar PV installation is typically connected to the electrical grid to ensure a stable and reliable power supply. Excess electricity generated by the system can be fed back into the grid, offsetting the energy consumption of the surrounding buildings or supplying power to other users.

Environmental Benefits: The solar PV installation helps to reduce reliance on fossil fuels and decreases greenhouse gas emissions associated with conventional electricity generation. By utilizing clean and renewable solar energy, the installation contributes to a more sustainable and environmentally friendly power source.

Cost Savings: Depending on the local energy policies and incentives, the solar PV installation can potentially lead to significant cost savings for the facility or property owner. By generating electricity on-site, the reliance on electricity from the grid is reduced, resulting in lower energy bills.

Maintenance: Regular maintenance and monitoring of the solar PV installation are necessary to ensure its optimal performance. This includes cleaning the panels, inspecting the system for any faults or issues, and replacing any faulty components if needed.

Overall, a 520 KW solar PV installation in a car parking area harnesses solar energy to generate electricity, providing environmental benefits, potential cost savings, and contributing to a more sustainable energy future.

CHAPTER V: CONCLUSION

My internship experience at the solar-based company Newsol PV Power Pvt. Ltd has been incredibly valuable and rewarding. Over the past few months, I have had the opportunity to work alongside a team of dedicated professionals and learn firsthand about the exciting field of solar energy.

Throughout my internship, I was involved in a variety of tasks and projects that allowed me to apply my knowledge and skills. I gained practical experience in conducting site surveys, analyzing solar energy potential, and assisting in the design and installation of solar systems. I also had the chance to collaborate with engineers, technicians, and project managers, which provided me with valuable insights into the different aspects of the solar industry.

One of the highlights of my internship was witnessing the positive impact of solar energy on the environment and communities. Seeing how solar installations can reduce carbon emissions and provide clean, sustainable energy was inspiring and reinforced my commitment to pursuing a career in renewable energy.

Furthermore, the solar company fostered a supportive and inclusive work environment. My colleagues were always willing to share their knowledge and provide guidance, which enhanced my learning experience. I was encouraged to ask questions, take on new challenges, and contribute to the team's goals.

During my internship, I also developed important professional skills, such as time management, communication, and problem-solving. These skills will undoubtedly benefit me in my future endeavours and contribute to my success in the renewable energy industry.

In conclusion, my internship at the solar company has been a transformative experience. It has deepened my understanding of solar energy and its potential as a sustainable solution. I am grateful for the opportunity to have been part of such an innovative and forward-thinkingcompany. I am excited to continue my journey in the renewable energy field, armed with the knowledge and skills I have acquired during my internship.

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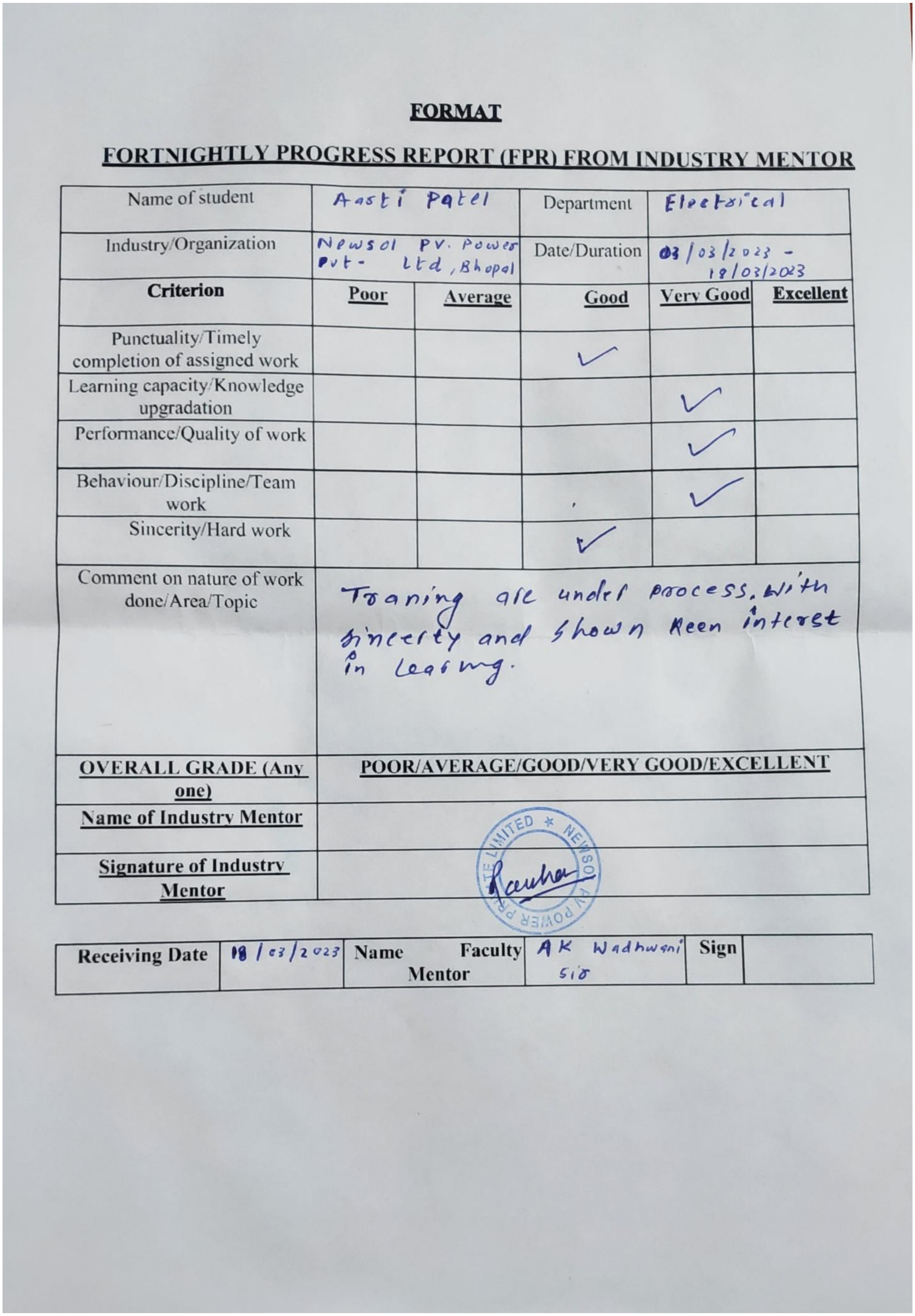
Appendix A: List of FPR



FORMAT

FORTNIGHTLY PROGRESS REPORT (FPR) FROM INDUSTRY MENTOR

Name of student	Aasti Patel	Department	Electrical
Industry/Organization	Newsol PV. Power Pvt- Ltd, Bhopal	Date/Duration	03/03/2023 - 18/03/2023

Criterion	**Poor**	**Average**	**Good**	**Very Good**	**Excellent**
Punctuality/Timely completion of assigned work			✓		
Learning capacity/Knowledge upgradation				✓	
Performance/Quality of work				✓	
Behaviour/Discipline/Team work				✓	
Sincerity/Hard work			✓		

Comment on nature of work done/Area/Topic	Traning are under process. with sincerty and shown keen interst in learing.
OVERALL GRADE (Any one)	**POOR/AVERAGE/GOOD/VERY GOOD/EXCELLENT**
Name of Industry Mentor	
Signature of Industry Mentor	Raushan

Receiving Date	18/03/2023	**Name Faculty Mentor**	A K Wadhwani sir	**Sign**	

FORMAT

FORTNIGHTLY PROGRESS REPORT (FPR) FROM INDUSTRY MENTOR

Name of student	Aarti Patel		Department	Electrical	
Industry/Organization	Newsol PV. Power Pvt. Ltd, Bhopal		Date/Duration	19/03/2023 - 02/04/2023	
Criterion	**Poor**	**Average**	**Good**	**Very Good**	**Excellent**
Punctuality/Timely completion of assigned work			✓		
Learning capacity/Knowledge upgradation				✓	
Performance/Quality of work				✓	
Behaviour/Discipline/Team work				✓	
Sincerity/Hard work			✓		
Comment on nature of work done/Area/Topic	Sincear and shown keen interest in leaing.				
OVERALL GRADE (Any one)	**POOR/AVERAGE/GOOD/VERY GOOD/EXCELLENT**				
Name of Industry Mentor					
Signature of Industry Mentor					

Receiving Date	02/04/2023	**Name Faculty Mentor**	A K Wadhwani sir	**Sign**	

FORMAT

FORTNIGHTLY PROGRESS REPORT (FPR) FROM INDUSTRY MENTOR

Name of student	Aarti Patel	Department	Electrical
Industry/Organization	Newsol PV. Power Pvt. Ltd. Bhopal	Date/Duration	03/04/2023 - 15/04/2023

Criterion	**Poor**	**Average**	**Good**	**Very Good**	**Excellent**
Punctuality/Timely completion of assigned work			✓		
Learning capacity/Knowledge upgradation				✓	
Performance/Quality of work			✓		
Behaviour/Discipline/Team work				✓	
Sincerity/Hard work			✓		

Comment on nature of work done/Area/Topic	
OVERALL GRADE (Any one)	**POOR/AVERAGE/GOOD/VERY GOOD/EXCELLENT**
Name of Industry Mentor	For NEWSOL PV POWER PVT. LTD.
Signature of Industry Mentor	Authorised Signatory

Receiving Date	15/04/2023	**Name Faculty Mentor**	Dr. A. K. Wadhwani	**Sign**	

FORMAT

FORTNIGHTLY PROGRESS REPORT (FPR) FROM INDUSTRY MENTOR

Name of student	Aarti Patel		Department	Electrical	
Industry/Organization	Newsol PV Power Pvt. Ltd, Bhopal		Date/Duration	18/04/2023 - 01/05/2023	
Criterion	**Poor**	**Average**	**Good**	**Very Good**	**Excellent**
Punctuality/Timely completion of assigned work				✓	
Learning capacity/Knowledge upgradation			✓		
Performance/Quality of work				✓	
Behaviour/Discipline/Team work				✓	
Sincerity/Hard work				✓	
Comment on nature of work done/Area/Topic					
OVERALL GRADE (Any one)	**POOR/AVERAGE/GOOD/[✓ VERY GOOD]/EXCELLENT**				
Name of Industry Mentor	For NEWSOL PV POWER PVT. LTD.				
Signature of Industry Mentor	Authorised Signatory				

Receiving Date	01-05-2023	**Name Faculty Mentor**	A.K. Wadhwani sir	**Sign**	

Appendix B: Self Evaluation of Fortnightly Progress of Internship

Contents of Fortnightly Progress of Internship

Weekly Report	Fortnightly Progress of Internship
Week-1	Visit to Industry
Week-2	Data Collection
Week-3	Site Visit Analysis of different components of PV system.
Week-4	Installation of Base Structure of Solar PV System
Week-5	Mounting of Panels on the structure and connecting them in series-parallel combination based on the number of strings available in the Inverters.
Week-6	Learnt about the basic functioning and connection of ACDB, DCDB Box and the inverter in the system.
Week-7	The connection of the Net-meter and the remaining connections are done to connect the PV System to the different loads of the Airport.
Week-8	Analysis of power generated by the PV system through a mobile app Shine Phone.

Appendix C: Role of Mentors (Duly Signed by Student and Mentor)

1. In this Internship our industry mentor Mr. Raushan Kumar sir is very supportive throughout the journey. From the first day to the last day of our Internship.
2. As the company works on the installation of a Solar Photovoltaic rooftop system. The mentor taught us about working and how to do the analysis of the different components involved in the setup of a System.
3. He explains the connection involved between the components of the setup. The net-meter installation and the supply from the utility grid.
4. In the office work we learnt how to register on the national portal after the installation of a Solar PV system and how to update the sanctioned load of the house.
5. We learnt how to analyse an electricity bill. Based on that we recommend the installation of a Solar PV system to the customer.
6. We learnt about the different subsidies offered by the government for the installation of domestic PV systems.
7. Above mentioned activities and works are done under the guided information of an industry mentor.

NEWSOL PV POWER PRIVATE LIMITED

Industry Mentor